Development of a Critical Angle Transmission Grating Spectrometer

Completed Technology Project (2017 - 2019)

Project Introduction

With APRA and SAT support, MIT has developed a unique blazed soft x-ray diffraction grating called the critical-angle transmission (CAT) grating. This device combines the high diffraction efficiency and resolving power of blazed reflection gratings with the low mass, low power, compact packaging and simple alignment of transmission gratings. We have shown that a spectrometer based on CAT gratings represents a huge leap forward in instrument scientific performance compared to previous missions, leading to much increased collecting area and spectral resolving power, which in turn results in orders-of-magnitude improvement in figures-of-merit for emission and absorption line spectroscopy. MIT proposes to bring CAT x-ray grating spectrometer (CATXGS) technology to a higher Technology Readiness Level (TRL). We will increase fabrication yield and grating performance, and develop bonding techniques for grating membranes and alignment techniques for grating arrays. We will build and test robust grating arrays for space deployment, and perform thorough environmental testing. We are very close to achieving TRL4 and ready to move on to TRL5, which we can achieve within the period covered by this proposal. Our rapid progress over the last year was made possible by significant prior investments in our infrastructure, but further progress will require further investments. Since 2007 we have - with NASA support - demonstrated the CAT grating principle, and prototypes of increasing quality and size have verified theoretical predictions, putting the technology at a solid TRL3. Recent NASA and MIT investments in fabrication and metrology infrastructure has been justified by our rapid progress during the last year: the fabrication of practically defect-free CAT gratings with record diffraction efficiency, the demonstration of extended bandpass CAT gratings using conformal deposition of thin metal films via atomic layer deposition (ALD), and the demonstration of record-setting resolving power for an XGS on the order of R = 10,000, which exceeds the requirements for all currently proposed mission concepts. Grating fabrication still consumes the lion's share of our efforts and time. In order to maintain momentum and continue progress towards TRL5 in an efficient manner we need to improve our fabrication infrastructure further to accelerate grating fabrication and increase yield, so we can devote more resources to the new work required for reaching TRL5.

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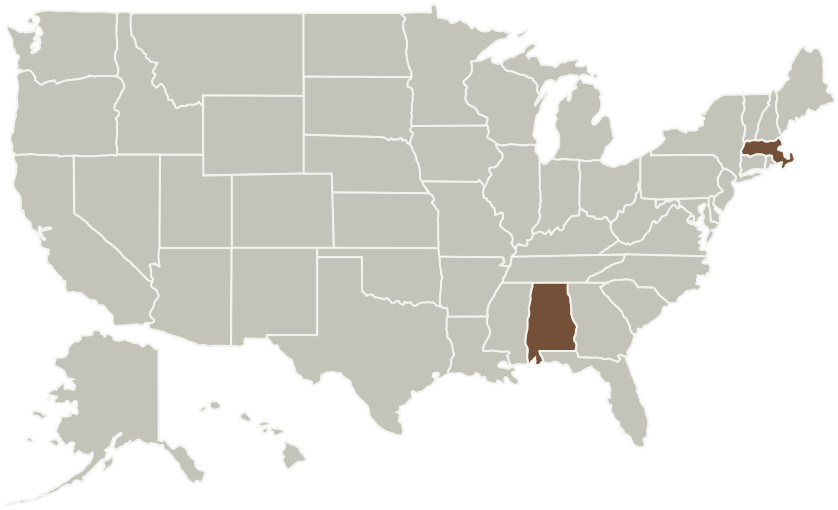
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations	
Alabama	Massachusetts

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Strategic Astrophysics Technology

Project Management

Program Director:

Mario R Perez

Program Manager:

Mario R Perez

Principal Investigator:

Mark L Schattenburg

Co-Investigators:

Veronica Anne Morris
Jeffery J Kolodziejczak
Ralf Helimann
Stephen L O'dell
Jessica A Gaskin
Alexander R Bruccoleri

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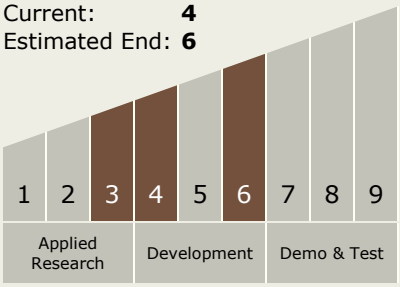
Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **6**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.1 Field and Particle Detectors

Target Destination

Outside the Solar System